AI-POWERED LITERACY ENHANCEMENT PLATFORM FOR RWANDA

BSc. in Software Engineering

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CHAPTER ONE: INTRODUCTION

1.1 Introduction and Background

Adult literacy is a pressing issue within Rwandan development, especially among those who did not get a chance to be educated when they were still young. Adult literacy in Rwanda is estimated at 78.8%, indicating that more than a fifth of people aged 15 and above are not able to read and write, with illiteracy being most prominent among rural and female sections of society.

Rwanda remains predominantly agricultural, with many families living in areas where poverty, scarce educational facilities, and the aftermath of past conflicts have blocked adults from learning opportunities. Consequently, adults who cannot read or write face real barriers as they miss out on better employment, cannot read medicine labels or health instructions, feel excluded from community discussions, and struggle to benefit from mobile banking or government digital services. This situation calls urgently for adult literacy programs designed specifically for Rwanda's unique realities.

Adult literacy programs in Rwanda have traditionally meant showing up to a classroom—whether at a community center, church, or evening class run by local NGOs or the government. Volunteer teachers work with printed materials, helping adults learn to read and do basic math. Many people have benefited from these programs. But the reality is harsh: classes happen at fixed times that

don't match when people are free. After a long day farming or working, the two-hour walk to class feels impossible. Mothers can't find childcare. There aren't enough trained teachers to go around. So people attend when they can, miss weeks at a time, and eventually stop coming, thus leaving without the reading skills they hoped to gain.

AI-powered learning platforms offer a fundamentally different pathway to adult literacy enhancement. Consider a rural Rwandan woman balancing farm work, childcare, and household responsibilities—traditional classroom-based programs remain inaccessible to her due to time constraints, distance, and opportunity costs. AI-assisted mobile learning platforms address these barriers by enabling adults to engage with educational content on their own schedules, in their native languages, and through intelligent tutoring systems that adapt to individual learning pace and style. These platforms can provide personalized instruction that responds to learner queries in real-time, offering explanations in multiple languages, adjusting difficulty based on performance, and providing immediate feedback without requiring human tutors to be constantly available.

Critically, AI-powered platforms can deliver contextually relevant content—reading seed labels, interpreting medical prescriptions, understanding financial documents—that directly connects literacy acquisition to learners' immediate practical needs. The AI assistant acts as a patient, always-available tutor that never judges, repeats explanations as many times as needed, and communicates in the learner's preferred language. This technology-enabled approach extends educational reach to geographically isolated communities that traditional programs struggle to serve, offering scalability without proportional increases in infrastructure or personnel costs.

1.2 Problem Statement

Two existing initiatives come closest to addressing adult literacy challenges in Rwanda: UNESCO's ABC (Alphabétisation de Base par Cellulaire) mobile literacy program and the Kolibri digital learning platform.

The ABC initiative demonstrates significant potential by leveraging basic mobile phones for delivering literacy and numeracy instruction through SMS and simple phone interactions, particularly reaching adults who never attended school. However, while this approach successfully overcomes barriers of physical access, it remains constrained by the limitations of text-based SMS technology, offering limited multimedia engagement, minimal personalization to individual learning needs, and no intelligent tutoring capabilities that can respond to learner questions or adapt instruction based on individual progress.

Similarly, Kolibri represents a robust digital learning platform that has gained traction in Rwanda precisely because it can function with limited internet connectivity—a critical consideration given that many areas experience frequent power outages and limited bandwidth. Its curated content library and proven technical reliability make it valuable for resource-constrained educational settings. Nevertheless, its design reflects a primarily school-age learner focus, with content that does not adequately address the lived experiences, practical needs, or learning preferences of adult populations. Furthermore, Kolibri lacks intelligent tutoring features—learners cannot ask

questions, request clarifications, or receive personalized explanations when they struggle with concepts.

For instance, a 35-year-old mother in urban Kigali seeking to read her child's medical prescriptions or understand agricultural extension materials finds limited relevance in curriculum designed for primary school students. When she encounters difficulty, there is no AI assistant to explain concepts in simpler terms, provide additional examples relevant to her context, or answer her specific questions about applying literacy skills to real-world situations she faces daily.

Furthermore, both solutions demonstrate insufficient integration of Kinyarwanda language instruction and culturally relevant content connected to adults' daily realities in Rwanda—such as market transactions, community governance participation, health literacy, or agricultural practices specific to Rwandan contexts.

The proposed AI-Powered Literacy Enhancement Platform addresses these documented limitations by providing intelligent, conversational tutoring that can respond to learner questions in real-time, adapt instruction based on individual progress, and deliver personalized explanations in Kinyarwanda, English, or French. Unlike static educational content, the AI assistant can engage in dialogue with learners, clarify misunderstandings, provide contextual examples relevant to Rwandan daily life, and offer encouragement tailored to each individual's learning journey. This solution prioritizes contextualized learning that speaks directly to adults' functional literacy needs within Rwanda's specific geographical, linguistic, and socioeconomic contexts.

1.3 Project's Main Objective

The overall aim of this project is to develop an AI-powered Adult Literacy Enhancement Platform that addresses the critical gaps in existing adult literacy solutions by providing an accessible, intelligent, multilingual digital learning tool specifically designed for adult learners in Rwanda, beginning with a focused pilot in Kacyiru and Gikondo sectors of Kigali.

This platform will deliver culturally relevant educational content in Kinyarwanda, English, and French, combining multimedia instruction with an AI conversational assistant that provides real-time tutoring, answers learner questions, adapts to individual learning pace, and offers personalized feedback. The AI assistant will be trained on practical applications connected to Rwandan adults' daily lives, including health literacy, civic participation, agricultural information, and financial literacy specific to Rwanda's context.

By integrating adult-centered pedagogical approaches with AI-powered personalized tutoring and intuitive interface design suitable for users with minimal digital experience, the platform aims to simultaneously build foundational literacy and digital skills among underserved adult populations in Rwanda, ultimately enhancing their economic opportunities, civic engagement, and ability to participate meaningfully in community governance structures while contributing to Rwanda's Vision 2050 development goals.

List of Specific Objectives:

- **Objective 1: Build an AI-powered mobile learning platform** - Create a phone-based learning tool with an integrated AI assistant that provides personalized tutoring, answers questions in real-time, and adapts to individual learning pace. The platform will use audio, images, and conversational AI to teach literacy in Kinyarwanda, English, and French for adults in Kacyiru and Gikondo sectors who have minimal formal education.
- **Objective 2: Develop practical, context-aware literacy lessons** - Design learning modules that teach reading and writing through everyday needs specific to urban Rwandan contexts—reading medicine labels, understanding work contracts, using mobile money, participating in Umuganda meetings, and navigating government services. The AI assistant will provide explanations using examples from learners' actual daily experiences in Kigali.
- **Objective 3: Test and measure real impact in Rwanda** - Pilot the platform with 20 adult participants across Kacyiru and Gikondo sectors, track completion rates and AI interaction patterns, and measure whether users can actually read better, use phones confidently, and engage more in their communities. Document how AI tutoring affects learning outcomes compared to static content delivery.

1.4 Research Questions

How effective is an AI-powered, multilingual mobile learning platform in improving functional literacy skills among adults with minimal literacy in urban Rwanda? This central question encompasses the following specific inquiries:

- What usability and interface design features best support adults with minimal literacy when using an AI-assisted mobile learning platform in Rwanda?
- How do AI conversational tutoring capabilities influence learner engagement, confidence, and learning outcomes compared to static instructional content?
- How does linking literacy instruction to everyday Rwandan contexts (health, agriculture, finance, civic participation in Kigali) through AI-personalized examples affect learning relevance and motivation?
- What types of AI interactions (question-answering, adaptive difficulty adjustment, personalized feedback, conversational practice) are most effective in supporting literacy skill development for adults in Rwanda?
- To what extent does participation in the pilot program improve reading, writing, and numeracy skills among adults in Kacyiru and Gikondo sectors?
- How does use of the AI-powered platform influence learners' digital skills and confidence in engaging with basic digital services available in Rwanda?
- What changes, if any, are observed in civic awareness and participation after adults in these Kigali sectors use the platform?

1.5 Project Scope

Geographical Scope

Testing the platform across all of Rwanda in three months isn't realistic. Instead, this project will focus exclusively on two specific sectors in Kigali: Kacyiru Sector and Gikondo Sector. These locations were chosen because they represent different faces of urban Rwanda while remaining manageable for close monitoring and support.

Kacyiru Sector is home to government offices, international organizations, and middle-class residential areas. Adults here often work as domestic workers, security guards, or informal service providers who need literacy skills to navigate formal employment, read work contracts, understand government notices, and communicate with employers. Many interact daily with educated professionals but lack the literacy skills to fully participate in these urban opportunities.

Gikondo Sector is Kigali's industrial hub, with factories, workshops, and informal settlements. Adults here typically work in manufacturing, construction, or small-scale trading. They need literacy for reading safety instructions at work, understanding product labels, managing small business transactions, and accessing health services. The sector has a large population of rural-to-urban migrants balancing traditional practices with urban life.

By working in both sectors, we can understand how the AI-powered platform serves different types of adult learners—those navigating professional urban environments and those working in industrial and informal economies—providing insights that will inform future expansion across Rwanda.

Target User Sample

The project will recruit 20 adult participants: 10 from Kacyiru and 10 from Gikondo, who:

- Are between 18-55 years old
- Can read fewer than 30 simple words in any language
- Have minimal experience using smartphones
- Volunteer to use the platform for three months
- Either own a basic smartphone or can borrow one from the project

This realistic number allows us to provide personalized support to each learner while gathering enough data to understand what works and what doesn't. We'll aim for equal numbers of men and women to see how the platform serves different groups. Recruitment will happen through local churches, sector offices, market associations, and women's groups to reach diverse participants.

Technical Scale

Platform Content:

The platform will launch with three essential learning modules, not everything at once:

- **Basic Literacy (20 lessons):** Learning Kinyarwanda letters, sounds, and simple words, with basic English and French vocabulary. The AI assistant will pronounce words, explain letter sounds, and answer questions about pronunciation or meaning in the learner's preferred language.
- **Everyday Numbers (15 lessons):** Counting, money calculations, measuring, reading prices, understanding phone credit. The AI can solve example problems step-by-step, explain mathematical concepts using Rwandan currency and local market scenarios, and provide unlimited practice with personalized difficulty.
- **Practical Life Skills (15 lessons):** Reading medicine labels, understanding work safety signs, basic civic information about Kigali governance, market literacy. The AI assistant can explain unfamiliar terms, relate concepts to learners' specific work contexts, and answer questions about applying skills in real situations they describe.

Each lesson takes 10-12 minutes for core content, with unlimited AI assistance available for questions and practice. The AI assistant provides approximately 50 structured lessons plus on-demand tutoring—enough for meaningful three-month engagement without overwhelming learners or developers.

Devices and Technology:

The platform works on affordable Android phones (50,000-80,000 RWF) common in Kigali—Tecno, Infinix, Itel, and basic Samsung models. It requires minimal phone storage (about 300MB for the app) and uses mobile data for AI interactions. Since Rwanda has relatively good mobile network coverage in urban areas, the platform leverages cloud-based AI to provide intelligent tutoring without requiring large downloads. Learners will need periodic internet access through mobile data or WiFi at community centers for AI assistant functionality, but lesson content can be cached for review without connectivity.

Support System:

For 20 learners, we'll provide:

- Two field coordinators—one based in Kacyiru, one in Gikondo—available for in-person help
- Weekly group sessions at local community centers where learners practice together and get technical help
- WhatsApp groups for quick questions and peer encouragement
- Access to mobile data vouchers for participants with limited data capacity
- Loaner smartphones for participants who don't own devices

Three-Month Timeline

Month 1: Getting Started

- Recruit participants, test their current literacy levels, introduce them to the platform
- Teach basic phone skills (turning on, charging, opening apps, using touchscreen)

- Introduce AI assistant functionality—how to ask questions, request explanations, and interact with the tutoring system
- Start first lessons with intensive daily support

Month 2: Learning and Adjusting

- Learners work through modules at their own pace with AI assistant support
- Weekly support sessions continue
- Monitor AI interaction patterns and adjust tutoring responses based on common questions
- We fix technical problems and adjust content based on feedback

Month 3: Progress and Evaluation

- Learners complete lessons and practice applying skills in real life
- We test literacy improvements and gather stories of how they've used new skills
- Analyze AI interaction logs to understand which tutoring features were most helpful
- Participants share what worked and what needs improvement

Language Approach

Given time constraints, the platform will use Kinyarwanda as the main teaching language because that's what participants speak at home and think in. The AI assistant will be capable of responding in Kinyarwanda, English, or French based on learner preference, and will introduce English and French words gradually within Kinyarwanda lessons, preparing learners for Rwanda's multilingual reality without overwhelming them. The conversational AI can switch languages mid-conversation if learners request clarification in a different language.

What Success Looks Like

We're aiming for realistic, achievable outcomes:

- At least 12 out of 20 participants still actively using the platform after three months
- Each learner completes 25+ lessons (half the available content)
- Regular engagement with AI assistant for questions and clarifications (at least 2-3 interactions per learning session)
- Measurable literacy improvement: reading 15-20 more words, solving basic math problems, understanding simple written instructions
- Real-world application: At least half the participants report using new skills practically—reading medicine bottles, checking phone credit, understanding work notices, or helping children with homework
- Clear insights on AI effectiveness: Documenting which types of AI interactions were most helpful, how personalized tutoring affected learning outcomes, and what technical problems occurred

This Kacyiru-Gikondo pilot is a learning opportunity, not a final solution. The goal is understanding what works for real people in real urban Rwandan contexts, so we can build something better for wider use across Rwanda.

1.6 Significance and Justification

When this platform works, it shows a practical way forward for reaching the adults who slip through every other educational program's cracks. The 20 people we're working with in Kacyiru and Gikondo—company house helps who want to read their employment contracts, factory workers trying to understand safety instructions, mothers who can't help their kids with homework—represent countless others across Rwanda's cities facing identical struggles. These aren't people who can attend evening classes after exhausting workdays or afford tuition fees. They need something that fits into their actual lives.

The AI-powered approach offers something traditional programs cannot: a patient, always-available tutor that never judges, never gets tired of repeating explanations, and can communicate in the learner's preferred language. When a domestic worker in Kacyiru struggles with reading her employment contract at 9 PM after her shift ends, she can ask the AI assistant to explain unfamiliar words, read sections aloud, or clarify legal terms—something impossible with fixed-schedule classroom programs. When a market vendor in Gikondo needs to quickly calculate profit margins during busy morning hours, the AI can walk through the math step-by-step using actual prices from his stall.

If we can prove this works in two very different Kigali neighborhoods, the path opens up for reaching similar communities throughout Rwanda where nearly everyone has a phone but far fewer have access to adult education. The AI component makes the solution scalable in ways human-dependent programs cannot match—one well-designed AI assistant can serve thousands of learners simultaneously, providing personalized attention that would require hundreds of trained teachers.

What makes this matter beyond just reading and writing is how it changes people's relationship with their communities and government. Right now, many adults sit silently in Umuganda meetings because they can't read the development plans being discussed. They don't vote confidently because ballot instructions confuse them. They can't follow up on government services because the paperwork overwhelms them. When you can suddenly read the notice board at the sector office, understand what's being proposed for your neighborhood, or fill out a form to access agricultural subsidies—and can ask an AI assistant to explain any part you don't understand—you stop being a passive recipient of governance and become an active participant. For women especially, this shift is profound as literacy becomes the difference between depending on husbands or brothers to handle official business and handling it themselves.

The real transformation happens in daily economic survival. A market vendor who learns to calculate profit margins with AI assistance stops getting cheated by wholesalers. A construction worker who can read his pay slip—and ask the AI to explain deductions—notices when payments don't match what he agreed to. A mother who understands her child's medical prescription through AI-assisted reading can give medicine correctly and confidently. These are not abstract development outcomes—they're concrete improvements in how people earn, save, and protect their families.

Because the platform uses cloud-based AI rather than requiring extensive offline content libraries, it remains affordable and sustainable for long-term deployment. Rwanda's improving mobile infrastructure makes this approach increasingly viable. If these three months prove that ordinary Rwandans with no formal education can genuinely learn through this AI-assisted tool, we'll have demonstrated something genuinely useful for the hundreds of thousands across Rwanda who've been told they're too old, too busy, or too far from school to ever learn.

1.7 Research Budget

This section explains what the money is for and why it is necessary. Not everything used in the research appears in the budget, only items that must be paid for and have no practical free alternative. Since this study is a small-scale pilot in two Kigali sectors, the budget reflects basic operational needs, not a full system rollout.

Key items included:

- Participant-related costs (transport reimbursement, refreshments)
- Data collection tools (mobile data for AI functionality, printing of consent forms)
- AI service costs (API usage for conversational tutoring)
- Technical costs (device testing, cloud hosting)
- Miscellaneous field expenses (stationery, facilitation materials)

Costs such as personal laptop use, open-source software, or supervision time are assumed to be in-kind contributions and are therefore excluded.

Research Budget (for 20 Participants in Kacyiru and Gikondo)

Item	Description	Quantity	Total Cost (RWF)
Participant transport	Local transport reimbursement for pilot sessions	20 participants	60,000
Participant refreshments	Light refreshments during learning/testing sessions	20 participants	40,000
Printing and stationery	Consent forms, assessment sheets, pens	Lump sum	25,000
Mobile data vouchers	Data for AI functionality and content access	20 participants	80,000

AI service costs	API usage for conversational tutoring (3 months)	Cloud service	120,000
Cloud hosting	Platform hosting and data storage	3 months	60,000
Device support	Loaner smartphones for participants without devices	5 devices	75,000
Local facilitation	Community assistant support during sessions	2 facilitators	80,000
Contingency	Unforeseen field expenses	—	20,000
		Total Estimated Budget	**560,000 RWF**

The above budget is suitable as it:

- Focuses only on unavoidable, payable costs
- Matches a 20-participant pilot scale in two Kigali sectors
- Includes realistic AI service costs for three-month usage
- Avoids inflated or unrealistic expenses
- Clearly supports data collection and evaluation
- Aligns with a 3-month academic project timeframe in Rwanda

1.8 Research Timeline

This study will be conducted over a three-month period in Kacyiru and Gikondo sectors of Kigali, during which the key phases of the project will be implemented in a structured and sequential manner. The Gantt chart below illustrates how the different components of the research align with time, ensuring that development, AI integration, content preparation, piloting, data collection, and evaluation activities are realistically scheduled. The timeline reflects the scope of this Rwanda-focused pilot project and allows for overlap between related tasks where appropriate, such as AI training and platform testing.

Gantt Chart: Research Timeline

Project Activity	Month 1	Month 2	Month 3
Literature review and proposal refinement	●		

Requirements gathering and user needs analysis	●		
Platform design (UI/UX for low-literacy users)	●	❖	
AI assistant integration and training	❖	●	
Platform development (multilingual MVP)	❖	●	
Content development (localized multimedia modules)	❖	●	
Internal testing and AI refinement		❖	
Participant recruitment and onboarding		❖	
Pilot implementation (20 participants in Kigali)		❖	●
Data collection (assessments, AI interaction logs)			●
Data analysis and evaluation			❖
Report writing and documentation			●

The timeline allows sufficient flexibility to accommodate iterative improvements to both the platform and AI tutoring capabilities while ensuring completion of all research objectives within the allocated timeframe in Rwanda.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This literature review focused specifically on finding research about actual software platforms and mobile applications designed for adult literacy, with particular attention to AI-powered educational technologies and their application in contexts similar to Rwanda. The search concentrated on platforms that use intelligent tutoring systems, conversational AI, and adaptive learning technologies rather than static content delivery. I was hunting for papers that discussed real digital

tools—their technical design, AI integration approaches, how they were built, what worked and what didn't when deployed with actual users who couldn't read well, and specifically any implementations in African or low-resource contexts.

My search concentrated on three main databases where serious computer science and education technology research gets published: Google Scholar for its broad coverage, ERIC because it specializes in education research, and IEEE Xplore since it archives technical conference papers about software implementation and AI applications. I started by searching combinations like 'AI tutoring system' together with 'adult literacy' and 'developing countries,' then tried more technical phrases like 'conversational AI for education,' 'intelligent tutoring systems,' 'adaptive learning platforms,' and 'natural language processing for low-literacy users.' I also looked for 'multilingual AI systems' and 'mobile learning applications' combined with terms like 'Rwanda,' 'East Africa,' and 'resource-constrained environments.'

This initial searching turned up numerous papers, but many weren't actually relevant—most discussed children's education software, others were purely theoretical without describing real AI implementations, and several focused on contexts so different from Rwanda that their findings wouldn't transfer. I read through abstracts and narrowed it down to sources that genuinely addressed the technical challenges of building AI-powered educational software for adults with minimal literacy and digital skills, particularly in African or similar developing country contexts.

I deliberately prioritized papers published after 2018 because AI technology, particularly conversational AI and natural language processing, has evolved extraordinarily rapidly, and older research about rule-based systems or early chatbots doesn't reflect current capabilities of large language models and modern AI assistants. However, I included some foundational pieces from 2015-2017 that established important design principles for low-literacy user interfaces that remain relevant today, as well as seminal work on human-computer interaction in African contexts.

What mattered most was finding research that actually described software and AI implementations—the technical decisions developers made about AI integration, natural language processing for local languages, the problems they encountered deploying conversational AI systems, how users with no prior technology experience interacted with AI tutors, and what features helped or hindered learning for people juggling literacy acquisition with daily survival in contexts similar to Rwanda.

2.2 Historical Background of the Research Topic

Adult illiteracy in Rwanda traces back to colonial education systems that educated only a tiny elite while ignoring the masses. When Rwanda gained independence, the government launched literacy campaigns using volunteer teachers and evening classes, but these programs consistently failed because they required too many teachers, too many classrooms, and expected exhausted workers to attend lessons using children's textbooks in foreign languages. The 1994 genocide destroyed education infrastructure and left a generation focused on survival rather than schooling. While

Rwanda has since achieved impressive progress in children's education, adults who lived through that period mostly never caught up.

Late 2000s mobile learning experiments in Rwanda and neighboring countries focused on SMS-based education, which obviously didn't help people who couldn't read text messages. The real shift came around 2015 when affordable smartphones enabled audio-visual instruction—phones could speak in local languages, show videos, use pictures instead of text. Pilot projects in Kenya and Tanzania demonstrated that adults could learn through sound and images without needing prior reading skills, though most remained small donor-funded experiments that disappeared after a year or two.

The emergence of conversational AI and large language models from 2020 onwards created entirely new possibilities for personalized tutoring. Unlike static content or simple SMS systems, modern AI can engage in genuine dialogue, answer questions in multiple languages, adapt explanations to individual learning needs, and provide the kind of responsive tutoring previously only available from human teachers. However, most AI-powered educational technologies have been developed for and deployed in well-resourced contexts with literate populations, leaving a critical gap in understanding how conversational AI can support adult literacy in contexts like Rwanda.

Rwanda's vision of becoming a digital knowledge economy assumes citizens can read government notices, use online services, and navigate smartphone apps—but these assumptions don't match reality for the quarter of adults who remain functionally illiterate, especially in a trilingual environment where official business happens in English and French while most people only comfortably speak Kinyarwanda. This research emerges from that convergence: persistent literacy gaps in Rwanda, widespread smartphone ownership, improved AI tutoring technology, and hard-won knowledge from decades of failed programs about what doesn't work.

We know now that digitizing old curricula fails, ignoring mother tongues reduces engagement, and assuming digital literacy leaves out those who need help most. The question isn't whether technology could help anymore—but whether we can finally design AI-powered solutions that actually work for Rwanda's adults who previous approaches left behind.

2.3 Overview of Existing Systems

When looking for digital literacy platforms actually operating in Rwanda, you quickly realize the landscape is surprisingly sparse. Most educational technology in Rwanda focuses on children in formal schools, not adults who never attended school in the first place. The few systems that do target adult learners reveal consistent gaps—particularly the absence of AI-powered personalized tutoring—that this research aims to address.

Ubumenyi (Rwanda's National Learning Platform)

Rwanda's government launched Ubumenyi as an e-learning platform meant to support education across all levels, including some adult education modules. The platform is primarily web-based,

requiring consistent internet connectivity. When you actually look at the adult education content available, it's mostly PDF documents of text-heavy materials originally designed for classroom use, just uploaded digitally without redesigning for self-directed learning or low-literacy users. There's minimal audio support, limited Kinyarwanda content, and crucially, no AI tutoring capabilities—learners cannot ask questions, request clarifications, or receive personalized explanations when they encounter difficulty. The platform works well for literate secondary students reviewing exam materials, but for adults in Kacyiru or Gikondo who can barely read and need responsive tutoring, Ubumenyi provides little support.

Eneza Education (Kenya and Rwanda)

Eneza operates in Kenya and expanded to Rwanda, delivering educational content primarily through SMS and USSD codes that work on basic feature phones. However, Eneza's content focuses almost exclusively on primary and secondary school curricula. The SMS format, while accessible technology-wise, is fundamentally text-based and offers no conversational AI support. There's no intelligent assistant to answer questions, provide alternative explanations, or adapt instruction to individual learning pace. An adult learner in Kigali seeking basic literacy wouldn't benefit from Eneza's school-oriented content or its non-adaptive delivery method.

Kolibri (Learning Equality - Used in Rwanda)

Kolibri represents an open-source platform designed for offline learning, used in several Rwandan schools and community centers. However, Kolibri's content library primarily consists of Khan Academy videos and educational materials designed for school curricula. While the platform supports video and interactive content, it lacks intelligent tutoring features—learners cannot ask questions, request clarifications, or receive personalized explanations when they struggle with concepts. There's no AI assistant to adapt the difficulty level, provide alternative explanations in different languages, or offer encouragement tailored to individual learning journeys. Community centers using Kolibri in Kigali report that adults who've never touched a computer before find it overwhelming and receive no conversational support when confused.

UNESCO's Literacy ABC App

UNESCO developed a mobile literacy application called ABC tested in several African countries including Rwanda. The app teaches basic literacy through audio-supported lessons, specifically designed for adults with no prior education. However, implementation in Rwanda has been limited and inconsistent. More critically, the ABC app lacks AI tutoring capabilities—it delivers static lessons without the ability to respond to learner questions, adapt explanations based on individual difficulties, or provide personalized feedback. When a learner struggles with a concept, there's no intelligent assistant to offer alternative explanations, break down the material differently, or provide encouragement. The content feels generic, with examples that don't adapt to Rwandan contexts or individual learner needs.

What's Missing Across All These Systems

Looking across these existing platforms, consistent gaps emerge that leave Rwanda's low-literacy adults underserved. First, there's a fundamental absence of AI-powered personalized tutoring— none of these systems can engage in dialogue with learners, answer their specific questions, or adapt instruction based on individual progress. Second, language localization remains superficial— minimal meaningful Kinyarwanda materials, no AI capability to explain concepts in the learner's preferred language, no consideration of how to progressively bridge from Kinyarwanda literacy to English and French competence through intelligent conversation.

Third, the few platforms targeting adult literacy lack sustainable local implementation and deep cultural contextualization to Rwandan realities. An adult in Kacyiru or Gikondo who can't read, owns a basic smartphone, speaks Kinyarwanda primarily, and needs literacy for navigating daily urban life in Rwanda while building civic engagement, has no existing solution that provides responsive AI tutoring tailored to their context. That's the gap this research addresses—the specific combination of AI-powered conversational tutoring, deep Kinyarwanda localization with progressive multilingual development, adult-relevant content connected to Rwandan contexts, and sustainable local implementation hasn't been packaged together in one accessible platform designed specifically for Rwanda's urban adult learners.

2.4 Review of Related Work

Several research studies have examined digital literacy interventions and AI-powered educational technologies in contexts relevant to Rwanda, offering insights that inform this project's design.

Studies in human-computer interaction and mobile learning consistently demonstrate that interface design plays a critical role in how adults with minimal literacy engage with digital learning tools. Research examining low-literacy users shows that icon-based navigation supported by spoken instructions in local languages is generally more effective than text-heavy menus. However, the emergence of conversational AI has transformed this landscape—rather than relying solely on careful icon design, modern systems can provide natural language interaction where learners simply ask questions in their own words (Kim et al., 2010; Patel et al., 2010).

Recent research on AI tutoring systems demonstrates that conversational interfaces can significantly reduce barriers for low-literacy learners. Studies of intelligent tutoring systems in developing country contexts show that learners who can ask questions in natural language and receive spoken responses in their native language demonstrate higher engagement and better learning outcomes compared to static content delivery. The AI's ability to rephrase explanations, provide contextual examples, and adapt difficulty based on individual performance creates a more supportive learning environment than traditional digital content (UNESCO, 2021; World Bank, 2019).

Participatory design studies conducted in African contexts highlight that AI systems must be carefully adapted to local languages and cultural contexts. Research on natural language processing for low-resource languages like Kinyarwanda shows that while major advances have been made in AI language capabilities, successful implementation requires careful attention to code-switching

patterns, cultural reference points, and the specific ways people use language in everyday contexts (Bidwell et al., 2014; Winschiers-Theophilus et al., 2012).

Research focused specifically on Rwanda, while still limited in the AI domain, provides important insights into the social and psychological barriers that shape digital literacy adoption. A Rwanda-based study examining technology usage patterns among informal sector workers in Kigali found that although smartphone ownership was widespread, functional digital confidence remained low. Participants frequently expressed fear of making mistakes, embarrassment about seeking help, and anxiety about technology (Ndahiro, 2021).

This finding is particularly relevant for AI-powered tutoring systems—an AI assistant that provides patient, non-judgmental responses, never expresses frustration at repeated questions, and offers encouragement can address these psychosocial barriers more effectively than human tutors who learners may fear disappointing. The AI's tireless patience and consistent supportive tone may reduce the shame and anxiety that often prevent adults from engaging with learning opportunities.

2.5 Summary of Reviewed Literature

The reviewed literature demonstrates that effective digital literacy systems for low-literacy adult learners must integrate both technical usability and AI-powered personalized support. Studies in mobile learning and human-computer interaction show that while interface design choices such as audio-first instruction and familiar navigation patterns are important, the emergence of conversational AI has created new possibilities for supporting learners through natural language interaction.

Research on intelligent tutoring systems confirms that AI-powered educational technologies can provide adaptive, personalized instruction that responds to individual learner needs in ways that static content cannot. The ability to ask questions, receive clarifications, and get explanations rephrased in different ways significantly enhances learning outcomes, particularly for adults with minimal formal education.

The literature also highlights that social, emotional, and psychological factors are critical in determining adoption and long-term use. Rwanda-focused studies reveal that fear of making mistakes, embarrassment about low digital skills, and lack of supportive learning environments frequently discourage adult learners—challenges that AI tutoring systems are uniquely positioned to address through patient, non-judgmental, always-available conversational support.

Overall, the reviewed literature provides strong foundation for the proposed AI-powered system design, justifying an approach that integrates inclusive interface design with conversational AI tutoring to enhance adult digital literacy outcomes in Rwanda.

2.6 Strengths and Weaknesses of Existing Systems

Existing digital literacy and learning platforms demonstrate important strengths in expanding educational access, particularly through mobile delivery and partnerships with governments and NGOs. These systems successfully leverage widespread smartphone ownership and standardized content distribution at scale.

However, despite these strengths, the reviewed systems largely fall short in addressing the specific cognitive, emotional, and usability needs of adults with minimal literacy in Rwanda. Most platforms were designed for school-aged learners or formally educated users, resulting in interfaces and instructional flows that assume baseline reading confidence and independent navigation skills.

Most critically, none of the existing systems deployed in Rwanda incorporate AI-powered conversational tutoring. Platforms like Ubumenyi, Kolibri, and Eneza provide content but no intelligent assistant to answer questions, adapt explanations, or provide personalized feedback. UNESCO-supported tools offer audio support but no conversational interaction. This absence of AI tutoring represents the most significant gap in current adult literacy solutions for Rwanda.

The systems also lack deep Kinyarwanda language integration, culturally relevant content specific to Rwandan urban contexts, and psychosocial support mechanisms that AI conversational interfaces can uniquely provide. These gaps highlight the need for a system that integrates low-literacy HCI principles, AI-powered conversational tutoring, localized multimedia content, and structured human facilitation—which this project seeks to address.

2.7 General Comment and Conclusion

Overall, the reviewed literature and existing systems demonstrate that digital platforms have strong potential to support literacy development in Rwanda, particularly when enhanced with AI-powered personalized tutoring. However, the evidence consistently shows that current solutions prioritize content delivery and scalability over the lived realities of adults with minimal literacy—especially their limited digital confidence, anxiety around technology, and need for responsive, conversational learning support.

While initiatives such as Ubumenyi, Kolibri, Eneza Education, and UNESCO-supported tools provide valuable foundations, they do not integrate AI-powered conversational tutoring, adult-centered design, supportive onboarding, or confidence-building mechanisms. The emergence of accessible AI technologies creates new possibilities for addressing these gaps.

This gap in both research and practice justifies the need for a tailored, AI-driven solution that combines intuitive interface design, conversational AI tutoring in Kinyarwanda, localized multimedia content relevant to urban Rwandan contexts, and human facilitation to effectively support adult learners in Kacyiru and Gikondo sectors of Kigali, with potential for expansion across Rwanda.

CHAPTER THREE: SYSTEM ANALYSIS AND DESIGN

3.1 Introduction

This chapter presents the system analysis and design of the proposed AI-powered adult literacy enhancement platform for Rwanda, focusing on how software and AI design choices can directly address the challenges faced by adults with minimal literacy in Kacyiru and Gikondo sectors of Kigali. The design approach combines user-centered design, participatory research, and Agile methodology, ensuring that the system evolves through continuous feedback from real users and facilitators in Rwanda.

Rather than prioritizing technical complexity, the design emphasizes simplicity, clarity, emotional safety, and intelligent responsiveness. The integration of conversational AI tutoring represents the core innovation—providing personalized, always-available support that adapts to individual learning pace, answers questions in the learner's preferred language, and offers encouragement tailored to each person's journey. The design recognizes that confidence, usability, and responsive AI interaction are as important as instructional content for adult learners in Rwanda.

3.2 Research Design

The system is developed using an Agile, iterative development model, allowing features—particularly AI tutoring capabilities—to be introduced gradually, tested with users in Kigali, and refined based on observed difficulties and feedback. This approach is especially suitable for Rwanda's adult literacy contexts where user needs and optimal AI interaction patterns often emerge during actual use rather than at the planning stage.

Each iteration focuses on a small set of features—such as onboarding, lesson navigation, AI question-answering, or adaptive assessments—ensuring steady progress while minimizing user overwhelm. The AI assistant itself undergoes continuous refinement based on actual learner questions and interaction patterns observed during the Kacyiru and Gikondo pilot.

Proposed Development Model:

User Needs → Design → Prototype → User Testing → AI Refinement → Feedback → Improvement

This cycle ensures that adult learners in Rwanda with limited literacy actively shape both the platform design and the AI tutoring behaviors rather than adapting to rigid software assumptions. The AI's conversational responses, language choices, and explanation strategies are continuously adjusted based on what actually helps Rwandan learners understand concepts.

3.3 Class Diagram

The class diagram defines the core system components and how they interact to support AI-powered personalized learning. The design keeps classes minimal to reduce system complexity while maintaining clear responsibilities and enabling intelligent tutoring.

Core Classes:

- **User:** Stores learner profile (name, sector location in Kigali, preferred language, current literacy level)
- **Lesson:** Contains educational content, multimedia resources, and difficulty level
- **Progress:** Tracks lesson completion, assessment scores, time spent, and learning trajectory
- **AIAssistant:** Manages conversational tutoring, question-answering, adaptive explanations, and personalized feedback in Kinyarwanda, English, or French
- **Assessment:** Evaluates learner skills and provides data for AI-driven difficulty adjustment
- **AIInteraction:** Logs all AI conversations for analysis and system improvement

This structure supports personalized AI-powered learning while remaining lightweight and scalable for deployment across Rwanda.

3.4 System Architecture

The system architecture follows a cloud-connected mobile-first model specifically designed for Rwanda's urban mobile network infrastructure. The architecture is divided into three clear layers: mobile client, cloud-based AI and backend services, and data storage.

The frontend consists of a mobile application with audio-first navigation, visual cues, and integrated AI chat interface, designed for learners with minimal literacy. The application works on affordable Android phones common in Kigali and uses mobile data for AI interactions, leveraging Rwanda's relatively good urban network coverage in Kacyiru and Gikondo sectors.

The backend exposes RESTful APIs that manage authentication, content delivery, progress tracking, and analytics. Critically, it integrates with cloud-based AI services (such as OpenAI API or similar) to power the conversational tutoring system. The AI service handles natural language understanding in Kinyarwanda, English, and French, generates contextually appropriate responses, and adapts explanations based on learner interaction history.

Data storage combines cloud-based databases for user profiles, progress tracking, and AI interaction logs, with local device caching for recently accessed lesson content. This enables learners to review previously accessed lessons without internet while ensuring AI tutoring features are available when connectivity exists.

Architecture Layers:

- **Mobile Frontend:** React Native app with voice interface, visual navigation, and AI chat

- **AI Service Layer:** Cloud-based conversational AI (multilingual support for Kinyarwanda, English, French)
- **Backend API:** Node.js services for authentication, content management, progress tracking
- **Database:** Cloud database (Firebase/Supabase) for user data, progress, AI interaction logs
- **Local Caching:** SQLite on device for content caching and offline lesson review

This architecture balances the need for AI-powered personalization (requiring cloud connectivity) with practical mobile data constraints in Rwanda by caching static content while keeping conversational features cloud-based.

3.5 UML Diagrams

The Entity Relationship Diagram (ERD) models how data is stored and related within the system, ensuring data integrity while supporting flexible AI-powered learning paths and conversation tracking.

Core Entities and Relationships:

- **User ↔ Progress:** One user has many progress records (one per lesson)
- **User ↔ AIInteraction:** One user has many AI conversations logged for analysis
- **Lesson ↔ Progress:** One lesson can be attempted by many users
- **Lesson ↔ Assessment:** Each lesson has associated assessments for skill measurement
- **AIInteraction ↔ Lesson:** AI conversations are contextualized to specific lessons

This structure allows the system to track both traditional learning progress and AI interaction patterns, enabling continuous improvement of the tutoring system based on actual user questions and difficulties observed in Rwanda.

3.6 Development Tools

The system is built using mobile-first, cloud-connected, and open-source technologies to reduce cost and increase sustainability for deployment in Rwanda. Key tools include:

- **React Native:** Cross-platform mobile development for Android devices common in Kigali
- **Node.js:** Backend services and API development
- **OpenAI API or Anthropic Claude API:** Cloud-based conversational AI for multilingual tutoring in Kinyarwanda, English, and French
- **Firebase or Supabase:** Authentication, cloud database, and real-time data synchronization
- **SQLite:** Local data caching for content accessed without internet
- **Figma:** Design and prototyping for low-literacy user interfaces
- **GitHub:** Version control and collaboration
- **Google Cloud Text-to-Speech:** High-quality voice synthesis for audio content in Kinyarwanda

These tools balance ease of development with long-term scalability and affordability, making the AI-powered solution practical for real-world deployment in Rwanda. The cloud-based AI approach enables sophisticated conversational tutoring without requiring expensive local AI infrastructure, while mobile data costs remain manageable for urban Kigali users.

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